



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



CONTENTS.

	Pages
Moon's Node, Mean Longitude of - - - - -	266
Obliquity of the Ecliptic - - - - -	266
Observatories, Longitude and Latitude of the Principal - - - - -	492 to 496
Occultations, of Stars by the Moon, visible at Greenwich - - - - -	452 to 453
<hr/>	
Elements for computing - - - - -	454 to 464
of Jupiter's Satellites by Jupiter - - - - -	XXI
Pallas, Ephemeris of - - - - -	313 to 315
for Opposition - - - - -	316 to 317
Parallaxes of the Planets - - - - -	359 to 361
Phenomena - - - - -	465 to 471
Pole Star, Tables to find the Latitude by - - - - -	485 to 487
Stars, Mean Places of, for 1837 - - - - -	362 to 364
Apparent Places of, for 1837 - - - - -	368 to 407
Constants, for Reduction of - - - - -	366 to 367
Logarithms, for Reduction of - - - - -	XXII
Formulæ, for Reduction of - - - - -	365
Correction of, for 2 ¢ - - - - -	408 to 409
Saturn, Ephemeris of - - - - -	335 to 346
Ring of - - - - -	472
Sidereal Time at Mean Noon - - - - -	II
Semidiامeters of the Planets - - - - -	359 to 361
Sun, Ephemeris of the - - - - -	I to III
Eclipses of the - - - - -	465 to 467
Aberration of the - - - - -	266
Parallax of the - - - - -	266
Terms, Law and University - - - - -	xii
Tides - - - - -	480 to 483
Time Equivalents, Tables of - - - - -	488 to 491
Transits of Jupiter's Satellites and their Shadows - - - - -	XXI
University Terms - - - - -	xii
Venus, Ephemeris of - - - - -	279 to 290
Phases of - - - - -	473
Vesta, Ephemeris of - - - - -	303 to 305
for Opposition - - - - -	306 to 307

APPENDIX.

On the Calculation of the Perturbations of the Small Planets and the Comets of short period. By Professor Airy - - - - -	149 to 171
On the Determination of the Longitude from an observed Solar Eclipse or Occultation. By Mr. Woolhouse - - - - -	172 to 183

EPHEMERIS
FOR THE YEAR
1837,
FOR THE MERIDIAN
OF THE
ROYAL OBSERVATORY AT GREENWICH.

CONFIGURATIONS OF THE SATELLITES OF JUPITER

At 12^h, MEAN TIME.

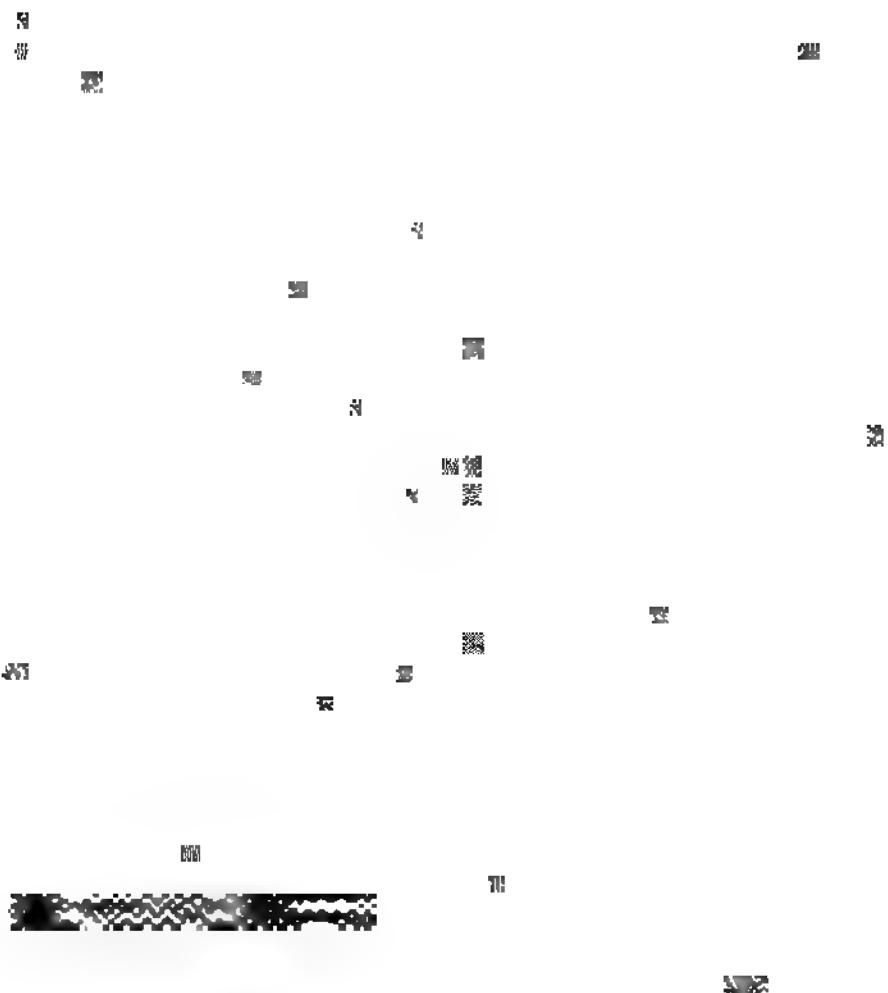
Day of the Month.	West.			East.		
1		4.	.2	O		.3
2		4.		O .1 ²		3.
3		4.		O 1.	3. 2.	
4		.4		O .1 ²		.1
5		.4	3.	O .2 ¹		
6		.4 .3		O 1. .2		
7				O 2.		
8			.2	1 O .4	.3	
9				O .2 ¹	.4	
10				O 3.		.4
11				O .1		.4
12		3.	.1 ²	O		4.
13			.3	O 1. .2		.4
14				O .1 .3	2.	.4
15			2.	O 1. 4. .3		
16				4 O	.3	
17			4.	O 1.	.2 ¹	
18			4.	O .2 ¹	.1	
19		4.	3.	O .2 1.		
20		.4	.3	O 1. .2		
21		.4		O .1 .3	2.	
22		.4	2.	O 1. .3		
23			.4	O .1 ²		.3
24	1. O			O .4	2. 3.	
25				O .2 ³	.1 .4	
26		3.	.2 1.	O		.4
27			.3	O .2 ¹		.4
28				O .2 ³		4.
29			2.	O 1. .3		.4
30				O .1 ²		.3 .4
31	O 1.			O	2. 3. 4.	

This Table represents, at 12^h after Mean Noon of each day of the month, the relative position of the images of Jupiter and his Satellites, as they would appear (disregarding their latitudes) in an inverting telescope. Jupiter is indicated by the white circles (O) in the centre of the disc, the Satellites by points. The numerals 1, 2, 3, and 4, annexed to the points, serve to distinguish the Satellites from each other; and their positions are such as to indicate the directions of the satellites' motions, which are in all cases to be considered as *towards the numerals*. When a Satellite is at its greatest elongation, the point is placed above or below the centre of the numeral. A circle (O) at the left or right hand of the page, denotes that the Satellite placed by the side of the disc of Jupiter, and a black circle (●) that it is either behind the disc, or in the shadow of Jupiter.

MEAN TIME.

PHASES OF THE MOON.

		d	h	m
●	New Moon - - - - -	4	22	7.8
▷	First Quarter - - - - -	11	21	38.3
○	Full Moon - - - - -	20	2	23.3
◁	Last Quarter - - - - -	27	17	30.8
◁	Perigee - - - - -	4	4	
◁	Apogee - - - - -	16	19	



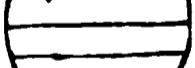
X.

MARCH, 1837.

65

ECLIPSES OF THE SATELLITES OF JUPITER.

JULY, 1837. - SATELLITES OF JUPITER.

SATELLITE.	Day of the Month.	Mean Time.	Sidereal Time.	PHASE as seen in an inverting Telescope.
I.	1	21 52 23.6	4 33 18.4	Em. 
	3	16 21 4.5	23 8 58.0	Em.
	5	10 49 49.8	17 44 42.0	Em.
	7	5 18 30.6	12 20 21.5	Em.
	8	23 47 15.9	6 56 5.5	Em.
	10	18 15 56.0	1 31 44.2	Em.
	12	12 44 40.6	20 7 27.6	Em.
	14	7 13 20.7	14 43 6.4	Em.
	16	1 42 4.4	9 18 48.8	Em.
	17	20 10 44.0	3 54 27.1	Em.
	19	14 39 28.0	22 30 9.7	Em.
	21	9 8 6.8	17 5 47.2	Em.
II.	2	13 36 36.4	20 20 6.3	Em. 
	6	2 53 59.2	9 51 29.8	Em.
	9	16 11 18.5	23 22 49.8	Em.
	13	5 28 34.7	12 54 6.6	Em.
	16	18 45 51.1	2 25 23.6	Em.
	20	8 3 2.4	15 56 35.6	Em.
III.	5	15 35 31.9	22 31 11.0	Em. 
	12	19 34 26.8	2 58 21.0	Em.
	19	23 33 8.5	7 25 18.0	Em.
IV.	11	0 26 13.4	7 42 42.5	Im. 
	11	5 8 43.1	12 26 18.6	Em. 

THE ECLIPSES OF THE SATELLITES OF JUPITER

are not visible

from the 22nd day of July until the 21st day of September,

JUPITER being too near to the SUN.

CONFIGURATIONS OF THE SATELLITES OF JUPITER

THE SATELLITES OF JUPITER

are not visible this Month,

JUPITER being too near to the SUN.

ECLIPSES OF THE SATELLITES OF JUPITER.

THE ECLIPSES OF THE SATELLITES OF JUPITER

are not visible this Month,

JUPITER being too near to the **SUN.**

APPROXIMATE SIDEREAL TIMES
OF THE
OCCULTATIONS OF JUPITER'S SATELLITES BY JUPITER,
AND OF THE
TRANSITS OF THE SATELLITES AND THEIR SHADOWS
OVER THE DISC OF THE PLANET.

THE SATELLITES of JUPITER

are not visible this Month,

JUPITER being too near to the SUN.

ECLIPSES OF THE SATELLITES OF JUPITER.*

LITE.	Day of the Month.	Mean Time.	Sidereal Time.	PHASE as seen in an inverting Telescope.
	21	5 33 32 .8	17 35 4 .4	Im.
	23	0 2 1 .5	12 10 31 .8	Im.
	24	18 30 34 .4	6 46 3 .4	Im.
	26	12 59 2 .1	1 21 29 .6	Im.
	28	7 27 34 .3	19 57 0 .5	Im.
	30	1 56 1 .9	14 32 26 .7	Im.
I.	22	4 18 49 .7	16 24 5 .6	Im.
I.	25	17 35 32 .9	5 54 49 .3	Im.
I.	29	6 52 15 .1	19 25 32 .1	Im.
I.	22	7 49 54 .2	19 55 44 .7	Im.
I.	29	11 48 31 .1	0 22 36 .7	Im.

* The Satellites are not visible until the 21st day of this Month,
Jupiter being too near to the Sun.



$f = -3^\circ 43$	$g = +7^\circ 67$	$G = 258^\circ 46$	$A = +19^\circ 48$	$H = 315^\circ 24$	$i = -5^\circ 93$
\times (in time) converted $= 79^\circ 6$ - - - - - $79^\circ 6$					
$G + a = \underline{\underline{337^\circ 52}}$	$H + a = \underline{\underline{34^\circ 90}}$				
Logarithms.	Nat. Nos.		Logarithms.	Nat.	
f	$- 3^\circ 43$				
$\sin (G+a)$	$+ 0.8848$		\cos	$+ 0.8848$	
$\tan \beta$	$+ 9.5761$			$+ 9.9668$	
	$+ 0.0357$			$+ 0.8516$	$+ 7^\circ 6$
	$- 9.4968$	$- 0.31$			
A	$+ 1^\circ 3896$			$+ 1^\circ 2896$	
$\sin (H+a)$	$+ 0.7531$		\cos	$+ 0.9160$	
$\sec \beta$	$+ 0.0025$			$+ 0.9331$	
	$+ 1.0452$	$+ 11.10$		$+ 0.2387$	$+ 1^\circ 6$
Δa (in arc)	$+ 7^\circ 36$				
Δa (in time)	$+ 0^\circ 49$		i	$- 0.7731$	
			$\cos \beta$	$+ 0.9975$	
				$- 0.7706$	$- 5.9$
				$\Delta \beta$	$+ 2.4$

$$\text{Hence the App. Right Ascens. of } \gamma \text{ Orionis} = 5^{\text{h}} 16^{\text{m}} 23\overset{\text{s}}{.}47 + 0\overset{\text{s}}{.}49 = 5^{\text{h}} 16^{\text{m}} 23\overset{\text{s}}{.}96$$

$$\text{And the Apparent Declination} = +6^{\circ} 11' 43\overset{\text{s}}{.}86 + 2\overset{\text{s}}{.}94 = +6^{\circ} 11' 46\overset{\text{s}}{.}80$$

been actually observed. The traveller has thus an opportunity of rendering his observations immediately available for determining his longitude with considerable accuracy.

The Right Ascension of the Moon's bright limb is given for the lower as well as the upper Colimation, *i. e.* being put to denote the Lower Colimation, and *c.* the Upper Colimation; the former is also distinguished by Italic Letters; the Roman numerals indicate the limb of the Moon with reference to its transit over the meridian. The Right Ascension of the Moon's bright limb is given for every day, with a view to the more accurate determination of its variation when required. The Moon's age at the time of her upper transit, to the nearest tenth of a day, is inserted in a parenthesis in the column containing the Magnitudes of the Stars.

The Declinations are given to the nearest minute, and are useful for pointing the instrument to the object.

The numbers in the column Var. of ♂'s R. A. in 1 hour of Long. represent the Variation in Right Ascension of the Moon's Limb during the interval of her transit over two meridians, equidistant from that of Greenwich, and one hour distant from each other. They have been deduced from the Right Ascensions of the bright limb, and therefore include the effect produced by the change of the semidiameter. They serve to determine the Longitude where the difference of meridians is not very great; but where this difference is considerable, and extreme accuracy is wanted, the variation in Right Ascension should be used which corresponds to the middle of the interval between the observations, which may be readily obtained by interpolation. They also serve to determine the Right Ascension of the bright limb at its transit over any other meridian. Thus: Multiply the difference of longitude between Greenwich and the given meridian, by the variation; and, according as the given meridian is east or west of Greenwich, subtract or add the product to the Right Ascension at Greenwich; the result will be the Right Ascension of the bright limb at transit over the proposed meridian. Example: On May 19, 1837, the Right Ascension of the Moon's first limb is $15^{\text{h}}\ 24^{\text{m}}\ 51\text{.}56$, at its upper transit at Greenwich, and the variation for one hour of longitude is $147\text{.}21$: Required the Right Ascension of the limb at its upper transit at Paris. Paris is $9^{\text{h}}\ 21\text{.}5$, or $0^{\circ}\text{.}156$, East of Greenwich; therefore, multiplying $147\text{.}21$ by $0\text{.}156$, and subtracting the product $22\text{.}96$ from $15^{\text{h}}\ 24^{\text{m}}\ 51\text{.}56$, we have $15^{\text{h}}\ 24^{\text{m}}\ 28\text{.}90$, for the Right Ascension at Paris.

Where an asterisk is placed opposite to a Star's name, it is intended to denote that the Star is favourably situated for observing its Declination along with that of the Moon in both hemispheres, with a view to the accurate determination of the Moon's Parallax.

The numbers in the column entitled Sid. Time of ♂'s Sem. pass. mer., express the Sidereal intervals which the Moon's Semidiameter, at the time of transit at Greenwich, takes in passing the meridian, and therefore serve to determine the Transit of the centre from an observed Transit of either limb.

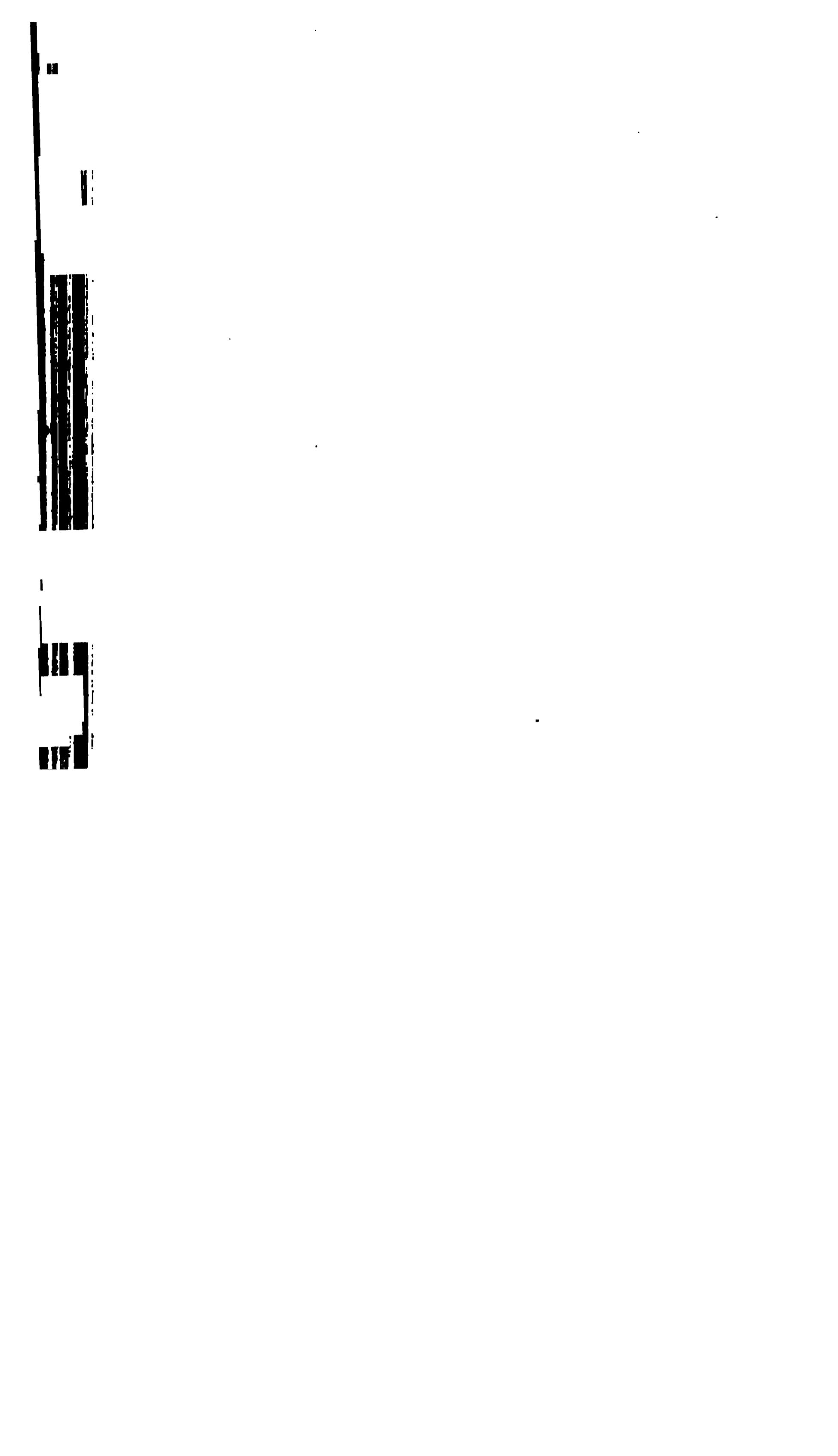
' Occultations. (Pages 452 to 453.)

These pages contain a list of the Planets and Fixed Stars to the sixth magnitude inclusive, the Occultations of which by the Moon will happen when the objects are above the horizon of Greenwich, together with the Sidereal and Mean Times of the Immersions and Emergions, and the points on the circumference of the Moon's image, where the Star, viewed with a telescope that inverts, will disappear and reappear. By

APPENDIX

TO THE

NAUTICAL ALMANAC FOR 1837.



or, as the quantity under the differential sign on the first side is $= \frac{1}{a}$,

$$-\frac{1}{a^3} \cdot \frac{da}{dt} = 2A \frac{dx}{dt} + 2B \frac{dy}{dt} + 2C \frac{dz}{dt}$$

$$\text{whence } \frac{da}{dt} = -2a^3 \left(A \frac{dx}{dt} + B \frac{dy}{dt} + C \frac{dz}{dt} \right)$$

from which the variation of the semi-major axis of the orbit is found.

(8) Now the longitude of m from the node is $\theta - \nu$ (θ being measured mentioned in (4)), and the co-ordinates of m parallel to the line of nodes, perpendicular to the line of nodes in the plane of the ecliptic, and perpendicular to ecliptic, are therefore $r \cos(\theta - \nu)$, $r \sin(\theta - \nu) \cos i$, and $r \sin(\theta - \nu) \sin i$. From these we readily obtain

$$x = r \{ \cos(\theta - \nu) \cos \nu - \sin(\theta - \nu) \cos i \sin \nu \}$$

$$y = r \{ \sin(\theta - \nu) \cos i \cos \nu + \cos(\theta - \nu) \sin \nu \}$$

$$z = r \sin(\theta - \nu) \sin i$$

and hence

$$\begin{aligned}
 (12) \quad \frac{d}{dt} &= \cos \nu \frac{d}{dt} \\
 &= \cos \nu \frac{d}{dt} \cdot \frac{h \sin i \sin \nu}{h \sin i \cos \nu} \\
 &= \frac{1}{h \sin i} \left\{ h \sin i \cos \nu \frac{d}{dt} (h \sin i \sin \nu) - h \sin i \sin \nu \frac{d}{dt} (h \sin i \cos \nu) \right\} \\
 &= \frac{1}{h \sin i} \left\{ \cos \nu \frac{d}{dt} (h \sin i \sin \nu) - \sin \nu \frac{d}{dt} (h \sin i \cos \nu) \right\} \\
 &= \frac{\mu}{h \sin i} \left\{ \cos \nu (Bx - Cy) - \sin \nu (Ax - Cx) \right\} \\
 &= \frac{\mu}{h \sin i} \left\{ A(-z \sin \nu) + B(z \cos \nu) + C(x \sin \nu - y \cos \nu) \right\}
 \end{aligned}$$

If we substitute for x and y the values in (8), we find

$$x \sin \nu - y \cos \nu = -r \sin(\theta - \nu) \cos i = -z \cot i$$

$$\text{Therefore } \frac{d\nu}{dt} = \frac{\mu z}{h \sin^2 i} \left\{ -A \sin \nu \sin i + B \cos \nu \sin i - C \cos i \right\}$$

$$\text{Let } -A \sin \nu \sin i + B \cos \nu \sin i - C \cos i = C'$$

Substituting the values of x , y , and z , from (8).

$$\begin{aligned}\frac{1}{h} \cdot \frac{dh}{dt} &= \frac{anr}{\sqrt{(1-e^2)}} \left\{ A \left(\sin(\theta-\nu) \cos \nu + \cos(\theta-\nu) \cos i \sin \nu \right) \right. \\ &\quad \left. + B \left(-\cos(\theta-\nu) \cos i \cos \nu + \sin(\theta-\nu) \sin \nu \right) - C \sin i \cos(\theta-\nu) \right\} \\ &= \frac{an}{\sqrt{(1-e^2)}} r B'\end{aligned}$$

And as $h = \sqrt{\mu} \sqrt{a(1-e^2)}$, we get

$$\begin{aligned}\frac{1}{h} \cdot \frac{dh}{dt} &= \frac{1}{2a} \cdot \frac{da}{dt} - \frac{e}{1-e^2} \cdot \frac{de}{dt} \\ \text{or } \frac{an}{\sqrt{(1-e^2)}} r B' &= - \frac{na^2 e}{\sqrt{(1-e^2)}} A' \cdot \frac{\sin(\theta-\omega)}{r} \\ &\quad + na^2 \sqrt{(1-e^2)} \cdot \frac{B'}{r} - \frac{e}{1-e^2} \cdot \frac{de}{dt}\end{aligned}$$

whence

$$\frac{e}{1-e^2} \cdot \frac{de}{dt} = - \frac{na^2 e}{\sqrt{(1-e^2)}} A' \frac{\sin(\theta-\omega)}{r} + \frac{na}{\sqrt{(1-e^2)}} (a^2(1-e^2)-r^2) \frac{B'}{r}$$

$$\text{and } \frac{de}{dt} = -na^2 \sqrt{(1-e^2)} \frac{\sin(\theta-\omega)}{r} A' + \frac{na \sqrt{(1-e^2)}}{e} (a^2(1-e^2)-r^2) \frac{B'}{r}$$

(15) Now $\frac{d(\log r)}{dt}$ is found by differentiating

$$\log r = \log a + \log(1-e^2) - \log \{1+e \cos(\theta-\omega)\},$$

which represents the correct value of $\log r$, because by (2) and (4) the same expressions are to be taken to represent the place of m (using the elements of the instantaneous ellipse), as those which are employed in undisturbed elliptic motion (using the elements of the permanent ellipse). Still it is to be borne in mind that the elements vary from one instant to another; and therefore their variation must be taken into account in forming $\frac{d(\log r)}{dt}$. Thus we have for $\frac{d(\log r)}{dt}$ the rigorous expression

$$\begin{aligned}\frac{d(\log a)}{dt} + \frac{d\{\log(1-e^2)\}}{dt} - \frac{d\{\log(1+e \cos(\theta-\omega))\}}{de} \cdot \frac{de}{dt} \\ - \frac{d\{\log(1+e \cos(\theta-\omega))\}}{d\omega} \cdot \frac{d\omega}{dt} - \frac{d\{\log(1+e \cos(\theta-\omega))\}}{d\theta} \cdot \frac{d\theta}{dt}.\end{aligned}$$

This expression, it is evident, has been obtained merely by considering that the *place* of m is always represented truly by the elliptic formulæ applied to the variable elements. But by (2) the *motion* of m is also to be represented truly by the elliptic formulæ for motion applied to the variable elements: and therefore generally the first differential coefficient with respect to t , of r or θ , or of any function of r or θ , must be

the epoch, the element by which the body's place in the orbit is found. For our purpose let us consider that θ , the longitude at the time t , depends upon a, e, ω and ϵ , inasmuch as it is expressed by the series

$$nt + \epsilon + (2e + \&c.) \sin(nt + \epsilon - \omega) + \&c.$$

where $n = \sqrt{\mu} a^{-\frac{3}{2}}$. The reasoning of (15), applied to this instance, shows that we must have

$$\frac{d\theta}{da} \cdot \frac{da}{dt} + \frac{d\theta}{de} \cdot \frac{de}{dt} + \frac{d\theta}{d\omega} \cdot \frac{d\omega}{dt} + \frac{d\theta}{d\epsilon} \cdot \frac{d\epsilon}{dt} = 0$$

The values of $\frac{da}{dt}, \frac{de}{dt}, \frac{d\omega}{dt}$, have been found; we have therefore only

to find the values of $\frac{d\theta}{da}, \frac{d\theta}{de}, \frac{d\theta}{d\omega}$, and $\frac{d\theta}{d\epsilon}$, and then the equation above will give

(18) For $\frac{d\theta}{da}$. Whatever be the definition of a differential coefficient, the differential rule for finding it is this: give to a the increment δa , and leave all other elements and the time unaltered; find the increment $\delta \theta$ which this causes; then take the value to which $\frac{\delta \theta}{\delta a}$ approaches when δa is made indefinitely small. Now θ is found in terms of t by integrating this expression

$$\frac{dt}{d\theta} = \frac{r^3}{h}$$

$$= \frac{a^2(1-e^2)^2}{\{1+e \cos(\theta-\omega)\}^2} \times \frac{1}{\sqrt{\mu} \sqrt{a(1-e^2)}}$$

If now we put $a + \delta a$ instead of a , $\frac{dt}{d\theta}$ becomes

$$\frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^2} + \frac{3}{2} \cdot \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \delta a \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^2} + \text{higher powers of } \delta a :$$

and integrating,

$$t = \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} f(\theta) + \frac{3}{2} \cdot \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \delta a (f(\theta) - \text{constant}) + \text{higher powers of } \delta a.$$

Putting $\theta + \delta\theta$ in the place of θ ,

$$t = \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} f(\theta) + \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \cdot \frac{d.f(\theta)}{d\theta} \delta\theta + \frac{3}{2} \cdot \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \delta a (f(\theta) - \text{constant}) \\ + \text{higher powers and combinations of } \delta a \text{ and } \delta\theta.$$

Making this value of t equal to the former,

$$\frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \cdot \frac{d.f(\theta)}{d\theta} \delta\theta + \frac{3}{2} \cdot \frac{a^{\frac{1}{2}}}{\sqrt{\mu}} \delta a (f(\theta) - \text{constant}) + \&c. = 0;$$

whence the limit of the value of $\frac{\delta\theta}{\delta a}$ is

$$= - \frac{3}{2a} \cdot \frac{f(\theta) - \text{constant}}{\frac{df(\theta)}{d\theta}} \\ = - \frac{3}{2a} \cdot \frac{\{1+e \cos(\theta-\omega)\}^2}{(1-e^2)^{\frac{1}{2}}} (f(\theta) - \text{constant.})$$

To determine the constant, it is to be remarked, that from the beginning we have assumed that in the instantaneous ellipse, whatever changes it may undergo, $nt + \epsilon$ is to represent the mean longitude: and therefore the variation of n (and consequently the variation of a on which n depends) must have t for a factor; and therefore its effect in $nt + \epsilon$, and in θ which depends on $nt + \epsilon$, must vanish when $t = 0$, or when $f(\theta) = 0$. From this we find,

$$\text{constant} = 0:$$

$$\frac{d\theta}{da} \text{ or the limit of } \frac{\delta\theta}{\delta a} = - \frac{3}{2a} \cdot \frac{\{1+e \cos(\theta-\omega)\}^2}{(1-e^2)^{\frac{1}{2}}} \cdot \frac{\sqrt{\mu}}{a^{\frac{3}{2}}} t \\ = - \frac{3}{2} na \sqrt{(1-e^2)} \frac{\{1+e \cos(\theta-\omega)\}^2}{a^2(1-e^2)^{\frac{1}{2}}} t \\ = - \frac{3}{2} na \sqrt{(1-e^2)} \frac{t}{r^2}.$$

The reader's attention is particularly invited to the circumstance, that in this investigation distinct reference is made to the assumption, that in the instantaneous ellipse the mean longitude is found by adding to the epoch the mean motion corresponding to that ellipse since $t = 0$.

+ higher powers and combinations of $\delta\theta$ and δe + constant $\times \delta e$.

Supposing t , and all the elements except e unaltered, this value of t must be same as if θ and e had no variations, that is it must be $\frac{1}{n} f(\theta)$. Consequently

$$0 = \frac{1}{n} \cdot \frac{d.f(\theta)}{d\theta} \delta\theta - \frac{\sqrt{1-e^2}}{n} \cdot \frac{\sin(\theta-\omega) \{2+e \cos(\theta-\omega)\}}{\{1+e \cos(\theta-\omega)\}^2} \delta e \\ + \text{higher powers, &c. + constant } \times \delta e$$

$$\text{whence } \frac{d\theta}{de} = \frac{\sqrt{1-e^2}}{\frac{d.f(\theta)}{d\theta}} \cdot \frac{\sin(\theta-\omega) \{2+e \cos(\theta-\omega)\}}{\{1+e \cos(\theta-\omega)\}^2} + \text{constant } \times \frac{n}{\frac{d.f}{d\theta}} \\ = \frac{\sin(\theta-\omega) \{2+e \cos(\theta-\omega)\}}{1-e^2} + \text{constant } \times \frac{n \{1+e \cos(\theta-\omega)\}^2}{(1-e^2)^{\frac{1}{2}}}.$$

To determine the constant we must observe that in the elliptic expressions the e part of θ which depends on e is the equation of the centre; and that this is 0, its variation produced by a variation of e is 0, when $\theta-\omega=0$; and therefore must have $0 + \text{constant } \times \frac{n(1+e)^2}{(1-e^2)^{\frac{1}{2}}} = 0$,

hence

$$\text{constant} = 0,$$

and therefore

$$\frac{d\theta}{de} = \frac{\sin(\theta - \omega) \{2 + e \cos(\theta - \omega)\}}{1 - e^2}.$$

(20) For $\frac{d\theta}{d\omega}$. As before, t is found by integrating (with respect to θ)

$$\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}}$$

when the longitude of perihelion is ω : and therefore when the longitude of perihelion is $\omega + \delta\omega$, t will be found by integrating

$$\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} + \delta\omega \frac{d}{d\omega} \left(\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \right) + \text{higher powers of } \delta\omega.$$

From the manner in which θ and ω enter into the last term, it is evident that

$$\frac{d}{d\omega} \left(\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \right) = - \frac{d}{d\theta} \left(\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \right);$$

and therefore t will now be found by integrating, with respect to θ ,

$$\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} - \delta\omega \frac{d}{d\theta} \left(\frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \right)$$

or the value of t is

$$\frac{1}{n} f(\theta) - \delta\omega \frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} + \text{higher powers of } \delta\omega + \text{constant} \times \delta\omega.$$

Put $\theta + \delta\theta$ in the place of θ , as before; this becomes

$$\begin{aligned} \frac{1}{n} f(\theta) + \frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \delta\theta - \frac{1}{n} \cdot \frac{(1-e^2)^{\frac{1}{2}}}{\{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}} \delta\omega \\ + \text{constant} \times \delta\omega \\ + \text{higher powers and combinations of } \delta\theta \text{ and } \delta\omega. \end{aligned}$$

From this as in the former cases,

$$\begin{aligned} \frac{d\theta}{d\omega} &= 1 - \text{constant} \times \frac{n \{1+e \cos(\theta-\omega)\}^{\frac{3}{2}}}{(1-e^2)^{\frac{1}{2}}} \\ &= 1 - \text{constant} \times \frac{na^2 \sqrt{1-e^2}}{r^2} \end{aligned}$$

To determine the constant, we have to observe that the only part for θ which depends on ω is the equation of the centre: and it

(22) Now substituting all the values in the equation of (17),

$$\begin{aligned}
 & -\frac{3}{2} na \sqrt{(1-e^2)} \frac{t}{r^2} \times \left\{ -2 \frac{na^3 e}{\sqrt{(1-e^2)}} A' \frac{\sin(\theta-\omega)}{r} + 2na^4 \sqrt{(1-e^2)} \right. \\
 & + \frac{\sin(\theta-\omega) \{2+e \cos(\theta-\omega)\}}{1-e^2} \times \left\{ -na^3 \sqrt{(1-e^2)} \frac{\sin(\theta-\omega)}{r} A' \right. \\
 & \quad \left. + \frac{na \sqrt{(1-e^2)}}{e} \{a^2(1-e^2) - r^2\} \frac{B'}{r} \right\} \\
 & + \left(1 - \frac{a^2 \sqrt{(1-e^2)}}{r^2} \right) \times \left\{ \frac{na^3 \sqrt{(1-e^2)}}{e} \cdot \frac{\cos(\theta-\omega)}{r} A' \right. \\
 & \quad \left. + \frac{na}{e \sqrt{(1-e^2)}} r \sin(\theta-\omega) \{2+e \cos(\theta-\omega)\} B' \right\} \\
 & + \frac{a^2 \sqrt{(1-e^2)}}{r^2} \cdot \frac{de}{dt} = 0
 \end{aligned}$$

$$\begin{aligned}
 \text{From which } \frac{de}{dt} = & \left\{ -3 \frac{n^2 a^3 e}{\sqrt{(1-e^2)}} t \frac{\sin(\theta-\omega)}{r} + 2na \right. \\
 & \left. + \frac{na^2(1-e^2)}{e} \left(\frac{1}{\sqrt{(1-e^2)}} - 1 \right) \frac{\cos(\theta-\omega)}{r} \right\} A'
 \end{aligned}$$

$$A = \frac{m_1}{\mu} \left\{ \frac{x-x_1}{\lambda_1^{\nu}} + \frac{x_1}{r_1^{\nu}} \right\} + \frac{m_2}{\mu} \left\{ \frac{x-x_2}{\lambda_2^{\nu}} + \frac{x_2}{r_2^{\nu}} \right\} + \text{&c.}$$

$$B = \frac{m_1}{\mu} \left\{ \frac{y-y_1}{\lambda_1^{\nu}} + \frac{y_1}{r_1^{\nu}} \right\} + \frac{m_2}{\mu} \left\{ \frac{y-y_2}{\lambda_2^{\nu}} + \frac{y_2}{r_2^{\nu}} \right\} + \text{&c.}$$

$$C = \frac{m_1}{\mu} \left\{ \frac{z-z_1}{\lambda_1^{\nu}} + \frac{z_1}{r_1^{\nu}} \right\} + \frac{m_2}{\mu} \left\{ \frac{z-z_2}{\lambda_2^{\nu}} + \frac{z_2}{r_2^{\nu}} \right\} + \text{&c.}$$

(38) Find the angles ψ and χ , where $\tan \psi = \tan \nu \cos i$, and $\tan \chi = \cot (\psi - \chi)$ will therefore be constants): and calculate for every middle day the following expressions:—

$$A' = Ax + By + Cz$$

$$B' = A \frac{\cos \nu}{\cos \psi} \sin (\theta - \nu + \psi) + B \frac{\sin \nu}{\cos \chi} \sin (\theta - \nu - \chi) - C \sin i \cos (\theta - \nu)$$

$$C' = -A \sin \nu \sin i + B \cos \nu \sin i - C \cos i.$$

(39) Find the angle ϕ , such that $\sin \phi = e$ (ϕ is therefore constant), and calculate for each middle day the following expressions (where p , as before mentioned, is the ordinal number of the interval)

The true longitude, calculated with the elements thus further corrected and the mean sidereal motion, for any considerable interval before and after the day for which the elements are computed, must also be affected with precession proportional to that interval. If, however, in the process of calculating true longitudes, the motion of precession be added to the mean sidereal motion, and if the same motion of precession be applied to the longitudes of the node and perihelion (neglecting for short times the effect of change of obliquity) it will not be necessary to take account of precession afterwards.

G. B. AIRY.

OBSERVATORY, CAMBRIDGE,

Dec. 3, 1834.

1

On the Determination of Longitude

*'s corr ^{d.} R. A. -	^h ^m ^s	10 21 13.83	
♂'s R. A. -	^h ^m ^s	10 20 58.47	
{ diff. - - - - -	^h ^m ^s	0 15.36	
common log. - - - - -		1.1864	
com. log. h. m. ♂'s R. A. -		2.0896	
Remainder - - - - -		0.9032	0.9032
const. log. - - - - -		0.4771	P. L. h. m. ♂'s dec. - - - - - 1.1871
corr. - - - - -	^h ^m ^s	0 7 29.9	P. L. 1.3803
Time assumed 11 0 0			corr. - - S. 0° 1' 27".7 P.L. 1.3803
Time corr ^{d.} -	^h ^m ^s	11 7 29.9	♂'s dec. - - N. 15 47 11.0
com. log. h. m. ♂'s R. A. - - - - -		2.0896	♂'s dec. corr. N. 15 45 43.3
con. ♂'s corr ^{d.} dec. - - - - -		9.9834	
sum (S ₁) - - - - -		2.0730	*'s corr ^{d.} dec. - - - - N. 15 37 47.3
P. L. h. m. ♂'s dec. - - - - -		1.1874	♂'s - - - - - N. 15 45 43.3
const. log. - - - - -		7.1427	{ diff. (* S. of ♂) - - - - 7.554
1st Orb. incl. - - N. 21°34' cot. 0.4031 - - sec. - - - - -			{ P. L. - - - - - 1.3563
			const. log. - - - - - 9.4354
			sec. - - - - - 0.0315
			0.8232
2nd Orb. incl. - - S. 61 9			P. L. ♂'s hor. par. - - - - - 0.5068
sum - - - - -	^h ^m ^s	8.39 35	sec. - - - - - 0.3164
			cosec. - - - - - 0.1957
			sum (S ₂) - - - - - 2.0730
			P. L. ♂'s hor. par. - - - - - 0.5068
			const. log. - - - - - 8.1844
			0.9599
corr. 0 19 44.5	^h ^m ^s	P. L. - - - - -	
Time corr ^{d.} 11 7 29.9			
Greenw ^h mean time - -	^h ^m ^s	10 47 45.4	
Equation of time - - -		6 31.0	
Greenw ^h app. time - -	^h ^m ^s	10 41 14.4	
Observed - - -	^h ^m ^s	10 39 22.4	
Longitude - - - - -		1 52.0 W.	

P.S.—The principle of reversing the effect of the relative horizontal parallax on the position of the Sun, instead of using the actual effect on the position of the Moon, may be advantageously employed in the direct calculation of an Eclipse for a particular place. It will only be necessary to use the parallaxes for the Sun viewed as an apparent position, and to diminish the semidiameter by the amount derived from the table on page 175. Thus, it appears, at the beginning of the Eclipse, for instance, that the contact may be mathematically tested in two ways. First, we may apply the actual effects of the parallax to the true position of the Moon, then augment her semidiameter, and thus establish a contact of the limbs. But, if we reverse the operation, and consider the Sun to be an apparent body under the influence of the relative parallax, then clearing it from this supposed influence by reversing the parallax, and

diminishing the semidiameter, a constant will similarly be associated with the true limb of the Moon; and this principle, in its application to solar eclipses, presents an advantage similar to that derived in the case of an occultation by considering the Sun as an apparent plane. (See *Appendix to Nautical Almanac* for 1851, page 125^o.)

The formulae, Nos. 2, 3, 4, and 5, pages 130 and 131 may, according to this method, be supplied by the following:

2. $P = p(P - \tau)$ $m = l' \cos i$
 $Q_1 = [9.4150] \quad Q_2 = [9.4150] m \sin i$
 $s = [9.43337] P$

3. $k = \frac{m}{\cos P}$
 $\Delta h \text{ in minutes} = [7.42052] k \sin \delta$
 $(h) = h - \Delta h$
 $\tan \theta = \cos(h) \cot l \quad G = \cos(h) \cos l$
 $\tan M = \frac{\sin \theta}{\cos(\theta + \delta)} \tan(h) \quad \tan \epsilon = \tan(\theta + \delta) \cos M$
 $B = \cos M \cos \epsilon$

check - - - $\frac{\sin \theta}{\cos(\theta + \delta)} = \frac{l}{B}$
 $\Delta \delta = B. l'$

$\sigma_0 = \sigma - \text{diminution for } \epsilon$
For $\left\{ \begin{array}{l} \text{partial} \\ \text{total or annular} \end{array} \right\}$ phase, $\Delta' = \left\{ \begin{array}{l} s + \sigma_0 \\ s - \sigma_0 \end{array} \right.$

4. $k_0 = \frac{m}{\cos \delta_0} \quad \Delta \alpha = k_0 \sin h$
 $\Delta \alpha_1 = Q_1 k_0 \cos h \quad \Delta \delta_1 = Q_1 \sin(h)$

5. $\delta_0 = \delta + \Delta \delta \quad \alpha' = \alpha - \Delta \alpha$
 $y = (\alpha - \Delta \alpha) \cos D \quad y_1 = (\alpha_1 - \Delta \alpha_1) \cos D$
 $x = (l) + \alpha' \text{ corr.} - \delta_0 \quad x_1 = D_1 - \Delta \delta_1$

* This was inadvertently ascribed to Carlini; Professor Henderson, by ~~w~~ appeared upon this very point, in the Quarterly Journal for 1824, page 411, that method has been long in practice, and that it was employed at an early period by

